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Recent Work on Aurora.

BY C. CHREE, Sc.D., F.R.S.

THE installation of an observatory in Shetland, having as one of its objects auroral observations, suggests a brief account of recent work on aurora. In this subject we owe much to Norwegian physicists, especially Professors Birkeland, Störmer, Vegard and Krogness. Aurora has many forms, of which arcs and curtains are the most frequently portrayed. But many, if not all, auroras are built up of rays. Aurora is usually a rapidly changing phenomenon, and the impression left on the ordinary observer may sometimes be more exactly reproduced by drawings than by photographs. The drawings of rays (Figs. 2–5) accompanying this article are from originals which refer to observations made in Jan Mayen in 1882.* Three of these drawings obviously suggest a radiant point, the fourth (Fig. 2) does not. The photograph (Fig. 1), which we owe to the kindness of Professor Störmer, represents a remarkable corona observed in Norway on the morning of March 23rd, 1920. As is generally known, Professor Störmer has devised a satisfactory method of measuring auroral heights by taking photographs simultaneously from the two ends of a base. (The photographs include stars, and the positions of the aurora relative to the stars on the two photographs enable the exact position of the aurora in space to be determined.) The corona shown here

* Die Internationale Polarforschung 1882–83. Die Österreichische Polarstation Jan Mayen, II. Band, I. Abtheilung, Plates VI. and VII.

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came near the end of a great auroral display (and magnetic storm), and the other base station had unfortunately exhausted its plates. The corona was remarkable, according to Professor Störmer, for its beautiful blue colour. The corona represents the convergence of auroral rays. The point of convergence has been observed at many stations, and found to make at least a close approach to the magnetic zenith. For instance, 11 observations made by Vegard and Krogness near Bossekop in 1913 gave values for the altitude of the point of convergence varying from 75·3° to 75·8°, the mean local value of the magnetic dip being 76·7°. This fits in with the theory, which we owe principally to Birkeland and Störmer, that aurora represents the passage through the earth's atmosphere of electrical rays, whether α (positive) rays or β (negative) rays, coming, it is supposed, from the sun. A group of α or β rays would naturally follow a spiral track about the earth's lines of magnetic force which give the direction of the dipping needle. The cylinder or cone on which the spiral is traced should be of larger diameter for the heavy α ray than for the β ray. According to Vegard and Krogness, an auroral ray produced by ordinary α rays could not be of less diameter than 12 km.; which is much in excess of their photographic determinations. These considerations seem to have converted (or perverted) Vegard, who used to be an ardent champion of α rays, into an acquiescence, perhaps temporary, in the β ray theory.

An obstacle to the acceptance of either theory undiluted is the large diameter of the auroral zone (or zone of maximum frequency) and the low geographical latitudes to which aurora extends. Another difficulty in the way of any theory which postulates rays all of one sign is the scattering that might be expected.

In latitudes such as the South of England aurora is seldom seen, and magnetic storms (*i.e.*, large long-continued disturbances) are rare. Thus their long known tendency to synchronize has naturally suggested a connection. Strong evidence of this can readily be derived without going further than the Geophysical Journal of the Meteorological Office. For some time the Journal has contained a monthly table specifying the dates when aurora has been seen in the United Kingdom, and giving the magnetic "character figures" (0 ≡ quiet, 1 ≡ moderately disturbed, 2 ≡ highly disturbed) assigned at Eskdalemuir and Kew to the days preceding and following the midnight to which the aurora is assigned. The mean "character" at the latter station for the auroral nights of 1919 was 1·12, the corresponding mean from the whole year being only 0·69.

To face page 86.

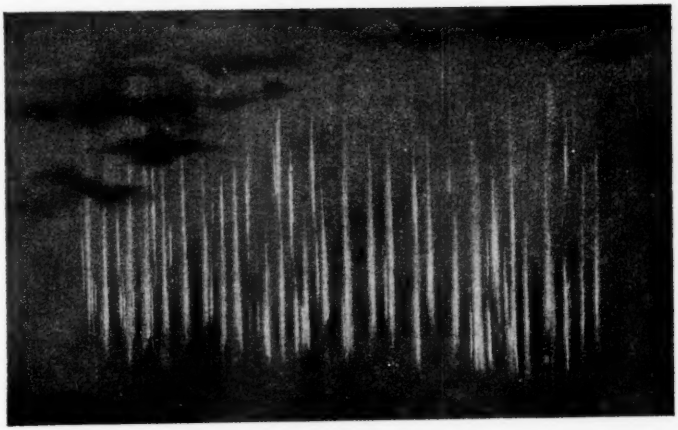

FIG. 2.—Rays at Jan Mayen, not showing convergence. (Strahlenreihe.)

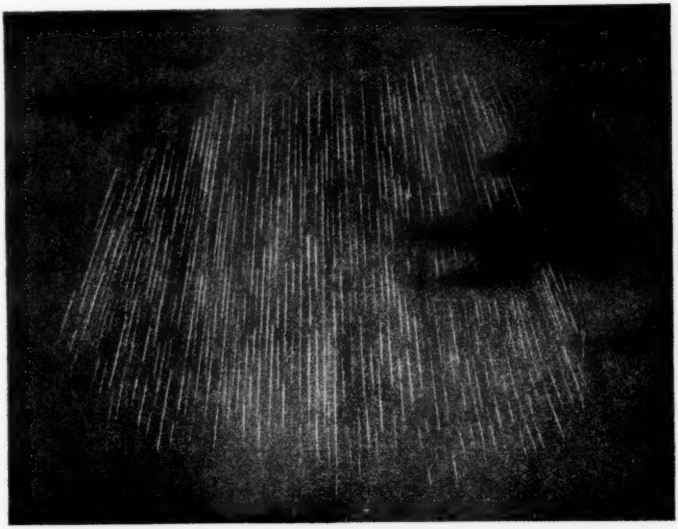

FIG. 3.—Rays at Jan Mayen, showing convergence. (Schleier.)

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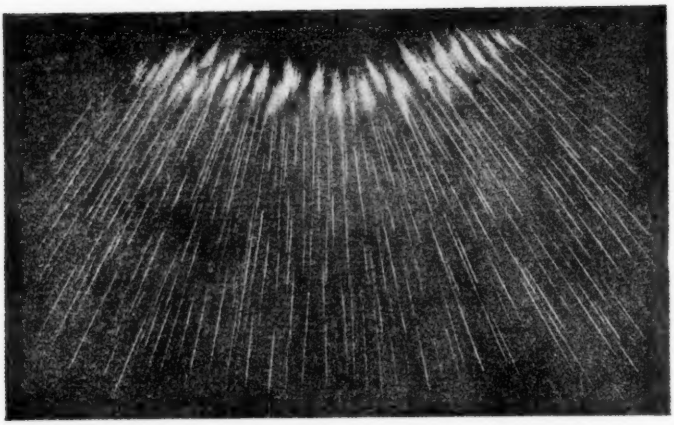

FIG. 4.—Rays at Jan Mayen, showing convergence. (Fadenwurf.)

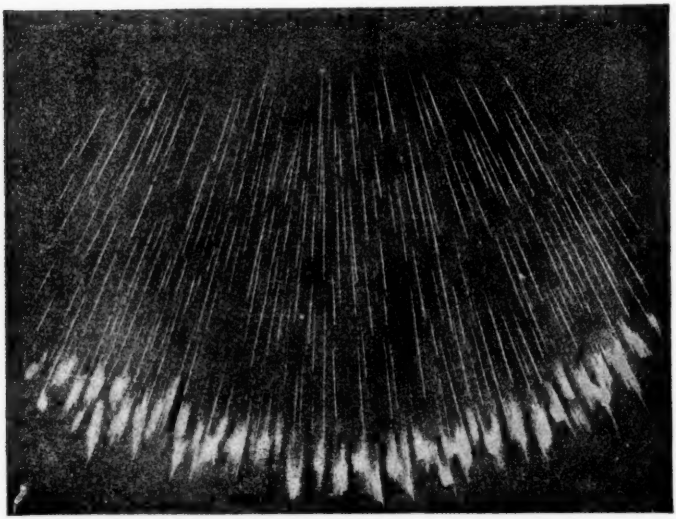

FIG. 5.—Rays at Jan Mayen, showing convergence. (Fadenmantel.)

A study confined to temperate latitudes being one-sided, some figures from the Scott Antarctic Expedition of 1911–12 may be of interest. In June and July 1911 (*i.e.*, midwinter) aurora was reported at 251 hours. The auroras being grouped in four classes in descending order of brightness, and magnetic "character figures" being assigned to individual hours, the resulting means were as follows* :—

Auroral class - - -	I.	II.	III.	IV.
Magnetic "character" - -	1·27	1·01	0·92	0·58

The mean magnetic "character" from all hours of the two months was 0·83. The fact that the hours when the faintest auroras were reported showed actually less than the average amount of magnetic disturbance would be curious if aurora were seen as seldom in high latitudes as in England. But in high latitudes aurora seems to be the rule, rather than the exception, when the absence of cloud and of strong moonlight permit of its being seen.

The spectrum of aurora offers another promising field of investigation. There is a characteristic auroral line, which Mr. Slipher† in America and Lord Rayleigh‡ in England have found may be photographed on most, if not all, nights, so that aurora invisible to the eye may be detected.

There are many other lines in the auroral spectrum some of which have been identified as due to nitrogen. If the spectrum is that of the surrounding gas, observations at different heights may convey information as to the composition of the atmosphere. From this point of view, rays such as one described in a recent paper by Professor Störmer, whose lowest and highest points were at heights of 140 and 400 km. respectively, might afford the same kind of information about the atmosphere that deep underground borings supply about the earth's geological structure. The heights just mentioned do not represent the extreme auroral limits. Heights under 90 km. have been measured on a good many occasions, and on March 22–23, 1920, one of Professor Störmer's heights exceeded 500 km.

It is also hoped that investigations into the spectrum of aurora may throw light on the electrical conditions of the upper atmosphere, and on the nature of the electrical rays which traverse it. Relations to wireless phenomena are also possible. In short, while the study of aurora may seem at present remote from practical applications, it would be rash to assert that such will always be the case.

* A difficulty in the way of estimating the exact degree of parallelism between magnetic disturbance and aurora is that neither element lends itself readily to exact numerical measure.

† Astrophysical Journal, Vol. XLIX., p. 266. ‡ Nature, Vol. 107, p. 137.

OFFICIAL NOTICES.

Sunshine Records.

OBSERVERS are requested to note that interpolations should not be made for the absence of "burn" during the eclipse of April 8th.

Official Publications.

Professional Notes, No. 15.—Diurnal Variation in Wind Velocity and Direction at Different Heights. By J. Durward, M.A. Price 9*d.* net.

THIS publication summarises the results of 1,736 pilot balloon observations (single theodolite) which reached 3,000 feet at Noyelle-Vion, on the British Front in France, from 1917 onwards. Ascents were made every four hours and provide a good basis for the investigation of the diurnal variation. The discussion is extended to a height of 6,000 feet, and each of the four quadrants is taken separately; it is found that the surface diurnal variation (maximum during day) is reversed in the free air, the minimum occurring about noon between 1,000 and 3,000 feet, but later, the higher one goes. At 4,000 and 6,000 feet there is a tendency for west winds to decrease and east winds to increase by day; three possible explanations for this are put forward. The importance of an analysis of this sort in making forecasts of the wind at different levels is obvious, as the variation is of quite sufficient magnitude to need allowing for, and in case of a long-distance flight may make all the difference between success and failure. In an addendum, accounts are given of similar investigations in Italy and at Batavia.

Professional Notes, No. 16.—The Use of Light Filters in the Observation of Pilot Balloons. By R. A. Watson Watt, B.Sc. Price 9*d.* net.

IN October 1919, Mr. R. A. Watson Watt began a series of experiments in the use of light filters in pilot balloon observations, and observers who are engaged in this work will welcome an account of his methods which greatly increase the distance to which a balloon can be followed, especially in haze, and at the same time make the conditions of observing less fatiguing. The Note deals briefly with the

purposes of a light filter, the types of filter employed in the investigation with their transmission data and absorption curves, and the great advantages to be derived from using them, which will readily be conceded by anyone with experience of following a balloon with and without a suitable filter. The choice of the best colour to employ depends on the state of the sky, the intensity of illumination, and the colour of the balloon. The most useful filters are yellow and red, particularly the "drastic reds." A white or light orange balloon against a cloudless blue sky has been found to give very satisfactory results with a red filter; when the background is a uniform sheet of white alto-stratus, alto-cumulus or cirro-stratus a dark blue or black balloon is preferable. The use of the very dense "monochromatic" filter is of great advantage when the balloon is nearly in line with the sun. A table showing the increase in balloon trajectories obtained by the use of filters reveals an advantage of 50 to 100 per cent. in favour of this method. In an appendix, a brief description is given of the making and mounting of an eye-piece filter system. Some time, care and patience are required for this operation, but when properly mounted the eye-piece is extremely easy to manipulate.

Professional Notes, No. 17.—Report on the Thunderstorm which caused Disastrous Floods at Louth on 29th May 1920. By E. V. Newnham, B.Sc. Price 9*d.* net.

A BRIEF description of the Louth floods has already appeared in this Magazine (June 1920, page 83); Mr. Newnham's longer report, based on a personal visit to the district, summarises all the available meteorological data. It appears that the rainfall exceeded 100 mm. (4 in.) over a strip of country twenty miles long and reached 121 mm. (4·75 in.) on the wolds west of Louth. (The scale of figure 1 is twenty and not ten miles to the inch.) This heavy fall in a few hours was concentrated in a narrow valley which became temporarily blocked, the breaking of the block being the immediate occasion of the flood. The ultimate cause of the downpour is shown to lie in two converging currents, one from south-west and the other from south-east, both very warm and moist, and at least 4,000 feet in depth, meeting near Louth. North of the Wolds a cold easterly current was blowing in from the North Sea, so that altogether conditions were very favourable for the ascent of great quantities of moist air and the resulting heavy precipitation.

The Herbertson Memorial Lecture.

THE second of the Memorial Lectures founded by the Geographical Association as a tribute to the late Professor Herbertson was delivered by Dr. H. R. Mill at the Royal Geographical Society on April 6th. Dr. Mill began by sketching the contributions of Edinburgh to the modern geographical movement, mentioning especially the work of Sir John Murray, Professor Geddes, the Geikies, and Drs. Buchan and Bartholomew. He then described his ideal of a regional geography of the British Isles, and pointed out that circumstances had led him to work at one aspect only of the great plan, namely, the relation of rainfall to configuration of the land. It was often assumed that surface relief controlled the distribution of rainfall, but years of rainfall mapping have shown that rain falling during thunderstorms or in cyclonic disturbances of comparatively small size is distributed in accordance with meteorological rather than geographical conditions, since it is probably determined at heights considerably above any part of the land. Moisture-laden air, rising because of some meteorological cause, produces rain whatever the land surface may be; but in the case of air flowing in from the sea or across low land, and forced upwards by hills, the amount of rain depends on the slope of the ground and the direction of the wind.

Dr. Mill spoke of the difficulties of mapping rainfall observations. At present the half-inch to the mile map can be used as a basis in most cases; the inch to the mile map rarely. Experience gives an almost instinctive insight into the sympathy between land forms and isohyets, but there are difficulties. The mapping of the rainfall on the slopes of uniformly rising ground such as the western face of the Welsh mountains, the Lake District, or Bowland Forest, so customarily gives increase of rainfall with height that it is disconcerting to find higher figures in the valleys to the east. It is a fact that places a few hundred feet above sea-level have higher rainfall than places a few thousand feet above sea-level to the windward of them, *e.g.*, the Stye below the Styehead Pass in the Lake District and the valley east of the Monmouthshire Black Mountains. Dr. Mill considered that this was due in part to the bodily transport of masses of rain-laden air over the ridge by high winds, and in part to the continual progress of the air blowing along the windward hill-slopes upward as well as onward. The general principles laid down in his article to British Rainfall, 1915, p. 28, were still sound, and these exceptions merely empha-

sized the rules. The lecture concluded with a consideration of the importance of the mapping of average rainfall, especially at the present day, when the difficulties of coal extraction are leading men's thoughts to the possibilities of water-power. The configuration of the land ensures that the heaviest rainfall descends on the head waters of a river, and therefore this is the region where most power can be generated. Special investigations are required to ascertain how much water flows off the surface and occupies the river bed at each point, how much evaporates, and how much percolates to deep-seated underground reservoirs. In order that a thorough survey into the hydrometric data and the consequent natural resources of the land may be made, co-operation between many departments, engineering, forestry, agriculture, geology, meteorology, is necessary; and trained geographers should then be able to co-ordinate the results for the benefit of the nation at large. The financing of such a comprehensive University School of Geography would be a great gift to the nation.

The Royal Meteorological Society.

THE usual monthly meeting of the Royal Meteorological Society was held on Wednesday, April 20th, in the Society's Rooms, Mr. R. H. Hooker (President) in the chair.

A paper was read by Mr. C. E. P. Brooks, entitled "The Evolution of Climate in North-West Europe." Mr. Brooks has previously discussed the influence of geographical conditions on climate, and has traced the widespread effect of comparatively small changes in the distribution of land and water. In the present paper he sets out to give a continuous account of the variation of climate in North-West Europe since the last Glacial Period. Several successive "phases" are distinguished:—

1. The Close of the Glacial Period, 30,000 to 18,000 B.C.
2. The Retreat of the Glaciers, 18,000 to 6,000 B.C.
3. The Continental Phase, about 5,000 B.C.
4. The Maritime Phase, about 4,000 B.C.
5. The Forest Phase, about 3,000 B.C.
6. The Peat Bog Phase, about 500 B.C.
7. The Recent Phase.

Charts are drawn to illustrate the probable meteorological conditions associated with each of these phases. Evidence is produced for the gradual shrinkage of a great anticyclone which covered Scandinavia and neighbouring regions during

the first two of the "phases." The Maritime Phase, when the winters were warm, is associated with a sinking of the land and a great extension of the Baltic. The Forest Phase implies a much drier climate than the present, the Peat Bog Phase a wetter.

To explain the climatic changes the mere geographical conditions are found sufficient in some cases, but in other cases different possibilities have to be taken into account. For example, the cessation of the Peat Bog Phase is shown to be contemporaneous with a marked drop in the rainfall of California and south-western Asia, known from Huntington's studies of the rings of trees, and must therefore be due to some widespread cause. Some of the changes of the last 3,000 years are seen to fit in very well with Pettersson's astronomical theory according to which periodical increases in the activity of the tides produce more thorough mixing of the waters of the oceans and take high temperatures further north.

Dr. G. C. Simpson, who opened the discussion, thought that the fact that cosmical causes were invoked to explain some of the changes of climate weakened the case for the predominating influence of the distribution of land and water in other phases. He was not satisfied that the formation of an incipient ice sheet would necessarily modify the atmospheric circulation sufficiently to account for its subsequent growth.

Professor Myres pointed out the importance to anthropologists of a knowledge of climatic conditions in the past. Much attention had been given to such questions in connection with the early history of Mesopotamia and Egypt.

In reply to Dr. Simpson, Mr. Brooks was able to give some results of mathematical analysis which tended to show that given sufficient area above the snow-line the growth of an ice-sheet would proceed rapidly.

A paper by Lieutenant Gordon C. Steele, V.C., R.N., entitled "A brief Review of the Influence of Meteorology on Naval Warfare," was, in the absence of the author, read by Captain Sir David Wilson-Barker.

The influence of meteorology on naval warfare can best be realised by briefly reviewing its effects in the past and comparing it with the present time. Starting as far back as the old war galleys propelled by oars, we find a certain independence of wind which their successors, the sailing ships, did not enjoy. The advent of steam, as we may suppose, rendered the warship independent of wind for movement and all that it involves; but, at the same time,

the progress of modern armament and the introduction of the long-range gun made the meteorological conditions of visibility of first rate importance. In fact, we may recollect that in almost every action fought in the late war some reference was made to the state of the weather. The last five years have seen new acquisitions to naval service, most notably the coastal motor-boat, a naval air wing, and such weapons as the smoke screen, and even the possibility of the use of poisonous gas at sea is now in sight.

Analysing the effect of meteorological conditions on these new arms, we notice that the last two are absolutely contingent on weather conditions and the others are so in a large degree. We are, therefore, justified in summing up that modern invention has not overcome the influence of meteorology on naval warfare, but we still find ourselves confronted with many of the old problems our ancestors had to deal with.

Moreover, its influence can be traced in the policy of ship construction. For example, in a programme of shipbuilding, the general climatology of the sea or ocean forming the probable theatre of war in a great measure determines the gun-range at which an action will be fought and consequently the amount of armour to be allocated under these conditions. From these considerations we are able to appreciate the value of an efficient Meteorological Service to the Navy.

Correspondence.

To the *Editors*, "*Meteorological Magazine*."

Optical Phenomena.

SOME interesting optical phenomena were witnessed at Croydon on the afternoon of April 11th. The day had been misty, with a considerable amount of low drifting cloud. Through breaks in these low layers cirrus and cirro-stratus clouds were visible. Early in the afternoon the low clouds gradually dispersed, the cirrus and cirro-stratus becoming more clearly distinguishable through the mist.

About 1.25 p.m. G.M.T. the upper arc of a 22° halo was noted. This arc was very strongly developed, the colours being particularly bright. To the right of the sun an arc of another circle (apparently a mock sun ring) was visible parallel to the horizon. This arc, which was a pale white colour, was at an elevation of about 42°. If produced it would have passed through the sun. It stretched from a point 30° to the right of the sun to the point immediately

opposite (*i.e.*, 180° away from the sun), where it was intersected by another arc, also of a pale white colour. This last arc, however, was very short—not more than 20°—and was visible for a few minutes only.

By 1.45 p.m. only the arc of the 22° halo was visible, with its intensity greatly diminished.

Although a sharp look-out was kept, no mock suns were observed. Coronæ were observed at 12.55 p.m. and at 3 p.m.

G. R. HAY.

Meteorological Office, Civil Aviation Aerodrome, Croydon, April 12th, 1921.

[In reply to a question concerning his observation, Capt. Hay writes that the arc through the anthelion was visible for too short a period to enable measurements to be made, but that he sketched it at the time; the inclination to the east of the vertical appears to have been about 15° and the arc was concave to the east.—ED. M.M.]

A REMARKABLE atmospheric phenomenon was witnessed from Carreg-y-Llan Quarries this afternoon:—

Mock sun ring. At 4.30 p.m. the sun was observed on the circumference of a large and complete circular ring of white against a blue sky relieved only by long parallel bands of fairly thick cirrus cloud.

Halo of 22°. On either side of the sun, at the points of intersection of a faint rainbow of half the diameter (or less) of the white circle, and the same, a brilliant rainbow

Parhelia, or mock suns. iridescence was noticeable; the portion of the rainbow above the sun was considerably flattened, while the portion below appeared to be sharpened—as far as could be seen, cliffs intervening to obscure a view of the base. The white ring might at a guess be placed at 45° elevation.

Upper arc of contact. These effects were visible up to 6 p.m., when an additional and more brilliant rainbow arc, inverted, became visible at a distance approximately equal to the radius of the complete rainbow.

HAROLD C. KING.

Victoria Hotel, Llithfaen, near Pwllheli, Carnarvonshire, April 19th, 1921.

[An account of a solar halo observed on April 20th, which is accompanied by accurate measurements and sketches, has been received from Eskdalemuir, and will be published in the next issue of this Magazine.

Solar halos with brilliant parhelia were also reported from Newquay on the 25th and Felixstowe on the 30th; a moon-pillar was observed at South Farnborough on April 24th.]

Simultaneous Halo and Corona.

CAPTAIN DOUGLAS's observation of the simultaneous halo and corona of December 25th, 1920 (*Meteorological Magazine*, January 1921, p. 274) may be paralleled by a recent occurrence here observed at 20 h. on January 19th, 1921. Although the sky appeared to be cloudless there was a faint complete lunar halo and a small corona. At the time there was a light south wind at the surface. My explanation of this phenomenon was that there was a thin cirro-nebula, the lower part of which had fallen into air having a temperature above freezing. The crystals of the upper portion would have been responsible for the halo, while the droplets formed by melting of the crystals in the lower portion would have accounted for the small corona. I do not see that the occurrence of super-cooled water-drops was necessarily involved in the case cited by Captain Douglas any more than in the case cited here.

Some discussion of the simultaneous occurrence of halos and coronas has been published in the *Monthly Weather Review* (Washington, D.C.) January 1919, Vol. 47, p. 21, and June 1920, Vol. 48, p. 333. CHARLES F. BROOKS.

Weather Bureau, Washington, D.C., February 26th, 1921.

[A letter from Mr. C. F. Brooks describing a similar phenomenon observed on March 20th, 1921, was published in the last number of the *Meteorological Magazine*, p. 69.]

The Terminal Velocity of Snow Flakes.

THE two heavy snow showers experienced in London in the afternoon and again in the early evening of Friday, April 15th, during the northerly type of weather then prevailing, were both characterised by a period during which the surface wind became dead calm. I took advantage of an opportunity during the calm period in the second heavy shower to measure the rate of fall of the snow flakes in still air. At the time, the snow consisted of dry flakes of many sizes, and a rough division into three groups was made by eye: large, averaging, say, three-quarters of an inch in diameter, medium and small, the latter averaging, say, one-quarter of an inch in diameter. Individual flakes were easily followed and the time taken to fall through a known height of 5·7 m. was measured by stop-watch. Unfortunately, the time available was short and only a very limited number of observations

were made—27 in all. They gave the following approximate terminal velocities :—

Large flakes - - - -	1·8 m/s,
Medium flakes - - - -	1·5 m/s,
Small flakes - - - -	1·1 m/s,

the larger flakes having the greater rate of descent.

These figures apply, of course, to snow of the particular texture of this occasion, but they may be used to obtain some idea as to the distance which snow, once formed, may be carried by the wind before reaching the ground. Thus, in the case of the medium flakes falling from a height of two kilometres through a column of air having a mean speed of 8 m/s (18 miles per hour), the distance would be only 24 k. (15 miles).

M. A. GIBLETT.

W. Hampstead, April 20th, 1921.

Velocity of Vertical Air Currents.

IN the report in the March issue of this Magazine of my contribution to the discussion of Mr. G. A. Clarke's paper on a pilot balloon ascent at Aberdeen, read before the Royal Meteorological Society, I am credited with saying that I had never met with such a large vertical current as that discussed by Mr. Clarke. This report is somewhat inaccurate. What I actually said was that I had only once met with a downward current of sufficient magnitude to prevent the balloon rising, while rising currents of over seven miles per hour (the rate found by Mr. Clarke) had been encountered four times in sixty-six ascents. The largest rising current ever measured by me was of eleven miles per hour. J. S. DINES.

April 29th, 1921.

I NOTE that in the *Meteorological Magazine* for March 1921, p. 38, it is stated that in a long series of observations with two theodolites vertical currents of six miles per hour had not been observed. In this connection two ascents made here on April 4th, 1921, may be of some interest.

1. *Start*, 11 h. 9 m. G.M.T. *Clouds*, Fr.Cu. 5. *Surface*, 43 ft./sec. at 300°.

Minute.	Velocity.	Direction.	Rate of Ascent.	Vertical Current.
	Ft./sec.		Ft./min.	Ft./min.
1	53	305	883	+ 383
2	34	313	877	377
3	31	324	1,393	893
4	41	313	1,447	+ 947

2. *Start*, 14 h. 20 m. G.M.T. *Clouds*, Fr.Cu. 7. *Surface*, 42 ft./sec. at 315°.

Minute.	Velocity.	Direction.	Rate of Ascent.	Vertical Current.
	Ft./sec.		Ft./min.	Ft./min.
1	42	326	586	+ 86
2	41	325	759	259
3	44	326	1,300	800
4	44	320	1,630	1,130
5	39	313	1,325	+ 825

Both balloons were filled to give an upward velocity of 500 feet per minute, and it will be observed that the maximum ascensional velocity is 1,630 feet per minute, or an upward current of 1,130 feet per minute (12 miles per hour). The average upward current in the second ascent from the 3rd to the 5th minutes is 918 feet per minute, or 10 miles per hour.

Slight snow fell at 15 h. 10 m.; the sky from 16–18 h. bore evidence of its disturbed state, large cumulo-nimbus with false cirrus being observed to the north and north-east.

J. DURWARD.

School of Artillery, Larkhill Camp, April 18th, 1921.

Units for Meteorological Work.

MAY I add a few words to the crisp little protest of Mr. Robert Cross in the April issue of this Magazine.

Mere clinging to accustomed usage is to be deprecated in scientific work if better methods or more expressive terms can be found. But the question is admissible whether millimetre is to be preferred to inch, and whether its use is likely to lead to a more popular understanding of rainfall news in this country. To each part of this question I judge that an emphatic *No* must be given.

1. If scientific facts can be equally well expressed in terms, one of which is simple and clear, the other more or less obscure and unfamiliar, it is pedantic to insist upon the more difficult.

2. The term "inch" is firmly embedded in the British mind. It is easily visualised, and thus no reader, however uninstructed, can fail to know what is meant by "an inch of rain."

If it is desired to make meteorology a close science, by all means let us invest it with a jargon of its own; but if we desire to popularise it, in order that the greatest possible number may take an intelligent interest in weather observa-

tion, let us use plain English. For purposes of comparison with foreign records it is not difficult to convert the terms.

Lexden, Colchester, April 21st, 1921. SAMUEL F. HURNARD.

NOTES AND QUERIES.

Fog and Mist.

THE indefiniteness of the terms fog, mist and haze has largely discounted the value of all statistics showing the frequency of these phenomena. The usage of ordinary life depends to a large extent on locality. To the townsman fog suggests the "London particular," yellow and smoky, but at sea a fog is white and objects can be seen, at any rate by day, at considerable distances. A definition of "fog" based on visibility must be of the nature of a compromise between the customs of land and sea. Such a compromise is made in a recent instruction issued by the Meteorological Office to observers.

According to this instruction, in daylight hours the use of the word fog is to be restricted to those occasions when the range of visibility falls short of one kilometre (1,100 yards). An entirely satisfactory criterion for use at night is not available. A light at night does not necessarily become invisible at the same distance as an object by day, when there is the same amount of opaque matter present in the air, but lights at different distances give the best assistance at present available for estimating the degree of obscurity. The official instruction is that "at night the descriptive terms and abbreviations are to be used to denote as nearly as possible the same degree of atmospheric obscurity." It is to be hoped that it will be found possible eventually to express this standard in terms of the distance of visibility of a light. The general adoption of the official definition will be a decided advance, however. Every observer should select a fixed object as near as may be to the specified distance of 1,100 yards. Fog is to be logged when this object cannot be seen by daylight.

As to the distinction between mist and haze, the rule of the Office is based on the amount of moisture present, as indicated by the readings of the dry and wet-bulb thermometer; provisionally a relative humidity of 80 per cent. has been adopted, but experience suggests that the rule itself requires modification. Investigations are in progress with a view to effecting an improvement.

The new instruction to which reference has been made includes a code for degrees of fog and mist, in terms of

visibility. This code and the visibility code adopted by the International Commission for Weather Telegraphy are incorporated in the following table:—

Fog Letters.	Description.	Specification. Objects not visible in Daylight at a distance of—	Visibility. Code Number.
8 f.	Very dense fog	25 metres *or* 27 yards	..
7 f.	Dense fog	50 ,, 55 ,,	0
6 f.	Thick fog	100 ,, 110 ,,	..
5 f.	Rather thick fog	200 ,, 220 ,,	1
4 f.	Fog	500 ,, 550 ,,	2
3 f.	Moderate fog	1,000 ,, 1,100 ,,	3
..	..	2,000 ,, 1¼ miles	4
2 m. *or* 2 z.	Mist *or* thick haze.	4,000 ,, 2½ ,,	5
..	..	7,000 ,, 4½ ,,	6
1 m. *or* 1 z.	Slight mist *or* haze.	12,000 ,, 7½ ,,	7
..	..	30,000 ,, 18½ ,,	8
..	..	Objects visible at above 30,000 m., *or* 18½ miles.	9

The fog and mist code has been used in the Daily Weather Report since March 1st, 1921.

Radiation from the Sky.

OBSERVATIONS on radiation from the sky are now made at Benson, Oxon., on most days. The instrument, which was described in the *Meteorological Magazine*, October, 1920, p. 189, measures primarily the equivalent radiative temperature of the part of the sky to which it is directed, but by using Stefan's formula for the radiation given off by a black body the strength of the radiation can be written down.

The strength of radiation from a definite source of light and heat is naturally measured as so much energy in a given time per unit area, so many watts per square centimetre. The radiation from a limited part of the sky depends on the solid angle which that part of the sky subtends, so that the strength of the radiation is given as so many watts per square centimetre per steradian, the word "steradian" being used in accordance with American practice for the unit of solid angle, *i.e.*, the solid angle subtended at the centre of a sphere of radius R by an area R^2 on its surface.

Very many different units have been used. Mr. Dines finds the gramme calorie per day of 24 hours a convenient measure of power. In the tables showing the results of observations J will be used for the total radiation received by a horizontal surface, the unit being the gramme calorie per day per square

centimetre, I will be used for the intensity of radiation received from a part of the sky and interrupted by a surface at right angles to the rays, the unit being the gramme calorie per day per steradian per square centimetre.

Instead of I, we tabulate πI, the advantage being that if I were the same for all parts of the sky, then πI would be equal* to J. The radiation from the earth is denoted by X, the unit being the same as for J.

For comparison with the units in more general use abroad and in official publications in this country we have the relations:—

1440 gm. cal./day cm.^{2} = 1 gm. cal./min. cm.^{2}.
20 gm. cal./day cm.^{2} = 1 milliwatt/cm.^{2}.

The system of observation provides for separate estimates of the energy of the rays, mostly luminous, which will pass through a glass plate, and of the dark heat-rays which are totally reflected from such a plate.

RADIATION MEASURED AT BENSON, 1921.

Averages for readings between 9 h. and 15 h.

	—	Jan.	Feb.
Cloudless Days: Atmospheric radiation only (dark heat-rays):—			
Radiation from sky in zenith	πI	431	445
Total radiation from sky	J	468	472
Total radiation from horizontal black surface on earth.	X	656	690
Net radiation from earth	X − J	188	218
Cloudless Days: Diffuse solar radiation (luminous rays):—			
Radiation from sky in zenith	πI_0	25	35
Total radiation from sky	J_0	41	60
Cloudy Days: Diffuse solar radiation (luminous rays):—			
Radiation from sky in zenith	πI_1	64	64
Total radiation from sky	J_1	71	70

The Observatory at Apia, Samoa.

THE observatory at Apia, Samoa, is the most important meteorological station in the Pacific; in fact, it is the only first-class station among the Pacific Islands. Its establishment in 1902 by the Königlichen Gessellschaft der

* For $J = \int I \cos Z \, d\omega = 2\pi \int_0^{\pi/2} I \sin Z \cos Z \, dZ$, where $d\omega$ is the element of solid angle and Z is the zenith distance.

Wissenschaften of Göttingen was due to the initiative of Weichert, the famous seismologist. The original intention was to make observations, meteorological, magnetic and seismological, for the year of the German South Polar Expedition, but the Government, which had from the first supported the enterprise, in 1904 renewed the grant for a period of five years. This grant was presumably again renewed in 1909.

The observations have been carried on continuously since the founding of the station, and were not appreciably interfered with by the recent hostilities. It is therefore satisfactory to learn that the observatory is now under the control of the External Affairs Department of New Zealand, so that this valuable series of observations is assured of continuity.

Thunderstorm at Edmonton on April 19th.

A VIOLENT thunderstorm which visited Edmonton between 6 and 7 p.m. on April 19th provides features of interest. We learn from the "Tottenham and Edmonton Herald" that lightning struck a poplar tree 40 feet high, not only splitting, but uprooting it, leaving a hole 4 feet wide. Apparently the adjacent house itself was struck almost simultaneously by a second flash, which ran from a chimney stack along a gutter and water pipe. Practically every window was blown out and several ceilings collapsed, besides other damage. Windows in the neighbourhood were broken over an area a hundred yards in diameter. Two people were burnt on the head and neck. One of these was a boy who was deaf; he and another lad, also deaf, partially recovered their hearing as the result of the shock. The storm was accompanied by snow as well as rain.

The general meteorological conditions were as follows:— An anticyclone centred over the British Isles on the 12th was replaced by a very extensive cold northerly current of air, which was maintained until the 20th. The temperature in the free air was very low at this time: 0° F. at 8,000 feet at Baldonnel and at 9,000 feet at Shoeburyness on the 15th, 0° F. at 10,000 feet at Baldonnel on the 16th and 18th. Thunderstorms occurred locally on the 17th, 18th and 19th; that at Edmonton was one of the last to occur because the supply of polar air was cut off about that time and the temperature aloft began to increase.

The extensive damage to windows is an unusual feature of a thunderstorm. It does not seem possible for such damage to be caused by the sound waves of ordinary thunder or by induced electric currents. Perhaps something akin to an explosion of ball lightning occurred.

Reviews.

El Clima de Punta Arenas a través de 31 años de Observaciones. Por José Re, S.S. 1920, pp. 122, charts.

THE Observatory "Monseñor José Fagnano," so called after its founder and first director, was established on the shores of the Magellan Straits in July, 1887, by the Salesian Mission, the head of which was the Rev. Don Bosco, a keen meteorologist, who initiated several stations in South America. The erection of an observatory at this point was first mooted at the International Committee for Polar Meteorology in 1880, but at that time the difficulties were too great. From 1888 regular observations were taken three times daily, and a first-class equipment of autographic instruments was speedily acquired, which has been kept up to date, though of late years with increasing difficulty.

Earlier summaries of the observations have been published by a former director, the Rev. P. Marabini; the present book reviews the whole set of data from the beginning of 1888 to the end of 1918, in fifty-four tables, dealing with temperature, pressure, rainfall, humidity, cloudiness, wind, sunshine (1916 to 1918), and evaporation. The data are given year by year, with averages for the whole period, and are illustrated by graphs, which in the case of temperature and pressure include daily means for ten years. Unfortunately no information is given as to the "phenomena"—days of rain, etc., and even important data like snow and fog are omitted. Several slips also appear in the arithmetical work, while the printing of minus signs is very slipshod, and anyone making extensive use of the normal values would be well advised to verify them wherever possible. Still more serious is it that the observations themselves are not always above suspicion; for example, the absolute minima for the seven months November to May are all shown as occurring in the season 1889 to 1890, but this is evidently due to a defect in the minimum thermometer, for during this period the mean daily minimum drops several degrees relatively to the temperature at 7 h. Further, the contemporaneous observations at Staten Island to the eastward show no such cold spell.

Faults like these are greatly to be regretted, for in their absence the amount of detail would make the book of great value to students of climatic variation, one or two interesting points being brought to light even in a casual examination. The spring rise of temperature shows a decided check between late October and mid November—a phenomenon resembling our May frosts on the opposite of the globe. It is also interesting to note that although there is no evidence of

the secular variation of temperature, there is a decided fall in both the daily and the monthly range after the year 1897. Several other interesting climatic features are pointed out in the accompanying text, particularly the unexpectedly high rates of evaporation, considering the general climate of the locality.

In 1911 another meteorological station was established at Punta Arenas by the Chilian Meteorological and Geophysical Institute, which must not be confused with the Salesian Observatory. It is interesting to note that in spite of their close proximity the temperature and rainfall at these two stations show considerable differences. C. E. B.

Meteorology, an Introductory Treatise. By A. E. M. Geddes. Pp. xx + 390, pl. 20, figs. 103. Blackie, 1921. 21s. net.

THIS is an elementary general textbook of meteorology, and one of the best of its kind yet published. The historical side is treated somewhat shortly, and the author devotes far the greatest part of his attention to modern methods and results. A brief but useful statement of propositions in the theory of correlation is given. The composition of the atmosphere at different heights and the distribution of dust particles are described in Chapter II.; Chapter III. deals with radiation, and Chapter IV. with temperature. Modern instruments are freely described, and a few pages on the temperature of the sea are included. Chapter V. concerns the theory of winds, especially the general circulation, land and sea breezes, and mountain winds. Chapter VI., on the water vapour of the atmosphere, occupies 53 pages, and treats the subject very thoroughly. The inclusion of some fine cloud photographs by G. A. Clarke adds further to the value of this chapter. Sunshine recorders are described, and an account is given of Taylor's fog results. Chapter VII. deals with the minor circulations of the atmosphere, including temperate and tropical cyclones, tornadoes, waterspouts, and line squalls. Chapter VIII. is devoted to the free atmosphere; it includes the results of W. H. Dines and others on the temperature and height of the stratosphere and the correlation between pressure and temperature at different heights. Atmospheric electricity, optics, and acoustics are described in succeeding chapters, and the last deals with weather forecasting and climate.

The profuse illustrations of high quality, including some coloured plates, form an important feature of the book. Ample references are given to literature quoted, and the index is good. H. J.

News in Brief.

SIR NAPIER SHAW will give the "Rede" Lecture at Cambridge on June 9th, on the subject of "The Air and its Ways."

ON April 23rd, Mr. G. I. Taylor delivered the Wilbur Wright Memorial Lecture before the Aeronautical Society at the rooms of the Royal Society of Arts. The subject of the lecture was "Scientific Methods in Aeronautics."

ON May 6th a Geophysical Discussion was held at the Royal Astronomical Society's Rooms, Burlington House, Dr. G. C. Simpson in the chair. The discussion, which was on "The Structure of the Atmosphere up to Twenty Kilometres," was opened by Sir Napier Shaw and continued by Col. E. Gold and Mr. W. H. Dines.

MESSRS. GAUTHIER-VILLARS ET CIE. announce the publication of the *Atlas Meteorologique de Paris*, by M. Joseph Lévine. The volume, the price of which is 20 francs, contains nine plates showing the variation of the meteorological elements from the year 1700, as well as thirty numerical tables and a *résumé* of the climate of Paris.

NEWS is received that the observatory at Chatham Islands was destroyed by fire in 1915, and that the observer unfortunately perished at the same time.

AN evaporation tank is now in use at Valencia Observatory, Cahirciveen. It is made of concrete instead of iron, as is more usual, and is believed to be the only evaporation tank in use in Ireland.

The Weather of April.

THE pressure distribution over north-west Europe underwent some very marked fluctuations during April, and the weather and temperature were in consequence very changeable. Between the 15th and the 20th very cold weather was general, and snow fell in many places in the British Isles and on the Continent. Night frosts were of frequent occurrence during the month, and reports in the Press showed that damage was done in many parts of England.

At the beginning of the month a belt of high pressure extending from the Azores to Central Europe maintained fair warm weather over the greater part of the British Isles. Temperature reached 69° F. in the screen at Aberdeen on the 1st, the highest figure yet recorded at that station in

THAMES VALLEY RAINFALL — APRIL 1881.

H.M. Stationery Office Press, Kingsway, W.C.2.

Ps. 3331/942. M. 28. 8. P.E. 1881. 4/31.

the first week in April. After the 3rd, depressions moving eastward along the Arctic circle caused cooler and less settled weather, especially in the north. Between the 6th and the 8th an anticyclone moved north-eastward over the British Isles to Scandinavia, and on the 7th and 8th the weather was cloudless over practically the whole of the British Isles, but there was a cold north-east wind and frost at night locally. A depression which was centred off the south-west coast of Italy on the morning of the 8th moved westward to the north-west of Spain by the 11th. A small secondary to this depression also moved west, and caused rain at a few German stations on the 8th and showery weather over England on the 9th. There were hail showers in many places, snow on the high ground in Derbyshire, and a thunderstorm at Sheffield, during which two horses were killed by lightning. In the rear of the secondary, fine weather appeared over Poland on the 8th and spread westward, extending from east to west over England during the 10th. At South Farnborough a maximum temperature of 68° F. was recorded on that day. The weather remained fair over the British Isles till the 13th, with warm days inland, but in France there were a few local thunderstorms, and some heavy rain in the extreme south.

At about this time there was a very complete change in the conditions over north-west Europe. The Scandinavian anticyclone broke up after the 10th, part of it moving away to south-east and the remainder passing in a south-westerly direction over the British Isles. A depression from the west reached the North Cape and became much deeper, and by the morning of the 13th there was a powerful northerly current between this depression and an anticyclone over Greenland, which soon spread over the whole of western Europe and caused a spell of very cold weather. At Kew Observatory the maximum temperature was 69° F. on the 13th, 50° F. on the 14th, and 41° F. on the 15th. There was also a large fall in the temperature of the upper air, amounting to 27° F. at 13,000 feet at Baldonnel (near Dublin) between the mornings of the 13th and 14th, with a further fall of 6° F. by the 15th, the figure being then −15° F. The incursion of the cold air caused a rain-line to advance over the British Isles during the 13th and the ensuing night, but the fall was nowhere very large. At 7 a.m. (G.M.T.) on the morning of the 14th there was a practically continuous line of rain from the Scilly Islands to Memel, on the Baltic, which continued to move south-eastward. A secondary depression, which developed near the Faröe Islands on the afternoon of the 13th, moved south-east to Denmark and became much deeper, intensifying the

northerly current over the British Isles and causing a gale on our eastern coasts and in the Irish Sea. Snow and hail showers fell very generally over the British Isles from the 14th to the 16th, but the amounts were not large. Frosts were experienced at night over a very large area; on the night of the 15th the screened thermometer fell to 18° F. at Eskdalemuir and to 21° F. at Benson, while at Howden a grass minimum of 13° F. was recorded. Maxima below 40° F. were observed at some northern stations. The Danish depression moved away north-north-east and filled up, but a new depression from Iceland moved in a south-easterly direction over the British Isles to France on the 17th, causing a fall of snow in many places, including London and Paris. Except on high ground the snow melted as it fell. The centre of the depression moved across south-east England during the afternoon, with dull weather and rain or snow in a cold south wind to the east of the centre, and variable skies with hail showers and local thunder in the warm north-west wind to the west. At 13 h. the temperature was 39° F. at Kew, but 48° F. at South Farnborough. The rainfall during the passage of the depression was general over the British Isles, but did not amount to an inch at any of the telegraphic reporting stations. The heaviest rainfall during the cold period was in eastern France, Belfort receiving a total of 77 mm. (3·1 inches) of rain and melted snow from the 14th to the 17th (inclusive).

In the rear of the depression of the 17th pressure rose decidedly over the British Isles, but the upper air temperature remained very low for a time, and thunderstorms were experienced locally over the British Isles on the 18th, and in eastern England on the 19th. On the evening of the 19th there was a sharp thunderstorm in North London, damage being done by lightning at Edmonton. There was further snowfall in parts of Scotland in the early hours of the 18th, and sharp night frosts were again experienced generally. Meanwhile cold disturbed weather continued further east. A depression moved up from the Adriatic to east Poland on the 17th and 18th, and then turned north-north-west and became very deep, being centred near Stockholm on the morning of the 19th. Severe gales occurred over Sweden, but the depression afterwards filled up quickly.

After the 20th conditions became rather milder over the British Isles, being influenced by two depressions which moved north-east over Iceland. The first of these depressions affected Spitzbergen and caused unusually heavy precipitation, apparently mainly in the form of rain. The measurement was 60 mm. (2·4 inches) on the 22nd and 36 mm. (1·3 inches) on the 20th; the total from the 19th to the 24th being

132 mm. (5·2 inches). A "V"-shaped secondary caused rain in Ireland on the night of the 20th, and then filled up, but another one followed it and caused rain over the whole of the British Isles, and local thunderstorms in Southern England, on the afternoon of the 23rd.

Another rapid change then took place in the pressure distribution. The depression which lay between Iceland and Greenland on the 23rd filled up rapidly, and an anticyclone spread up from the south-west and joined another anticyclone which had formed over Northern Scandinavia, forming a long ridge of high pressure. The "V-shaped" secondary which crossed the British Isles on the 23rd dispersed quickly, its southern extremity being absorbed by another disturbance which moved westward from Poland, secondary to a deeper depression which had formed over the Mediterranean. The secondary depression which moved west caused heavy rain on the Continent on the 23rd (Hamburg, 50mm., Belfort, 95 mm.), and small amounts in eastern England on the night of the 24th. For the rest of the month the pressure distribution was dominated by a large anticyclone over Scandinavia, which moved slowly westward, being centred near the Faröe on the 30th. There was a general easterly to north-easterly current over western Europe, with mainly fair weather. In the British Isles there was much cloud till 27th, but it then became fair. Local thunderstorms were experienced at a few western and midland stations on the 27th and 28th, and on the south coast on the 30th. Temperature reached 70° F. at several stations in southern England and on the Continent, and exceeded 80° F. in southern France.

Visibility over the British Isles was mainly good during the month, but there was local morning fog on the opening days and on the 26th and 27th. There was also some local sea-fog in the last week, especially on the east coast. Clouds were very low all day in south-east England on the 17th and 24th.

In the Mediterranean area the weather was mainly of an unsettled cyclonic type. There were some heavy falls of rain, including one of 42 mm. at Gibraltar on the 10th, of 37 mm. at Rome on the 16th, and of 38 mm. at Malta on the 22nd. A fall of 115 mm. (4·6 inches) at Gibraltar on March 31st, which was overlooked in last month's article, is worthy of mention.

C. K. M. D.

Rainfall of the British Isles: April, 1921.

THE rainfall appears to have been deficient in all parts of the country except a portion of East Anglia. The deficiency was greatest in the south-west of England and Wales, the south of Ireland, and south and centre of Scotland, in all of which districts less than half the average fell. A narrow

(*Continued on* p. 112.)

Rainfall Table for April 1921.

STATION.	COUNTY.	Aver. 1881—1915.	1921.		Per cent. of Av.	Max. in 24 hrs.		No. of Rain Days
		in.	in.	mm.		in.	Date.	
Camden Square	*London*	1·54	1·29	33	84	·34	17	10
Tenterden (Ashenden)	*Kent*	1·62	1·48	38	91	·48	17	9
Arundel (Patching Farm)	*Sussex*	1·75	·91	23	52	·35	16	9
Fordingbridge (Oaklands)	*Hampshire*	1·83	1·23	31	67	·44	16	12
Oxford (Magdalen College)	*Oxfordshire*	1·54	·91	23	59	·28	13	12
Wellingborough (Swanspool)	*Northampton*	1·49	·90	23	60	·25	13	11
Hawkedon Rectory	*Suffolk*	1·54	1·76	45	114	·50	13	13
Norwich (Eaton)	*Norfolk*	1·71	1·71	43	100	·55	13	11
Launceston (Polapit Tamar)	*Devon*	2·34	·74	19	32	·18	17	8
Sidmouth (Sidmount)	„	2·13	·88	22	41	·28	16	8
Ross (Chasedale Observatory)	*Herefordshire*	1·89	·63	16	33	..	..	..
Church Stretton (Wolstaston)	*Shropshire*	2·16	1·33	34	62	·46	14	11
Boston (Black Sluice)	*Lincoln*	1·35	1·03	26	76	·30	13	12
Worksop (Hodsock Priory)	*Nottingham*	1·47	1·05	27	71	·22	*13	12
Mickleover Manor	*Derbyshire*	1·73	1·17	30	68	·26	13	12
Southport (Hesketh Park)	*Lancashire*	1·85	1·40	35	76	·57	13	10
Harrogate (Harlow Moor Ob.)	*York, W. R.*	1·84	1·26	32	68	·27	9	13
Hull (Pearson Park)	„ *E. R.*	1·56	1·02	26	65	·38	13	13
Newcastle (Town Moor)	*North'land*	1·64	1·35	34	82	·32	†18	11
Borrowdale (Seathwaite)	*Cumberland*	7·42	2·40	61	32	..	..	..
Cardiff (Ely Pumping Stn.)	*Glamorgan*	2·53	·84	21	33	·28	16	10
Haverfordwest (Gram. Sch.)	*Pembroke*	2·62	1·02	26	39	·44	22	10
Aberystwyth (Gogerddan)	*Cardigan*	2·61	1·82	46	70	·62	13	8
Llandudno	*Carnarvon*	1·81	1·15	29	64	·61	13	11
Dumfries (Cargen)	*Kirkcudbrt.*	2·67	1·26	32	47	·46	16	11
Marchmont House	*Berwick*	2·02	·68	17	34	·11	‡16	10
Girvan (Pinmore)	*Ayr*	2·97	1·78	45	60	·56	22	10
Glasgow (Queen's Park)	*Renfrew*	1·97	·58	15	29	·20	16	6
Islay (Eallabus)	*Argyll*	2·87	2·40	61	84	·59	22	13
Mull (Quinish)	„	3·30	3·18	81	96	·86	16	17
Loch Dhu	*Perth*	4·74	2·20	56	46	·75	16	9
Dundee (Eastern Necropolis)	*Forfar*	1·70	1·04	26	61	·62	17	7
Braemar (Bank)	*Aberdeen*	2·31	·83	21	36	·15	14	8
Aberdeen (Cranford)	„	2·05	1·73	44	84	·73	17	11
Gordon Castle	*Moray*	1·75	·68	17	39	·18	13	10
Fort William (Atholl Bank)	*Inverness*	4·43	2·27	58	51	·42	§12	13
Alness (Ardross Castle)	*Ross*	2·42	1·53	39	63	·42	14	10
Loch Torridon (Bendamph)	„	5·22	3·92	100	75	·77	14	16
Stornoway	„	3·03	2·50	63	83	·36	12	14
Wick	*Caithness*	1·99	1·03	26	52	..	..	..
Glanmire (Lota Lodge)	*Cork*	2·80	·71	18	25	·32	16	10
Killarney (District Asylum)	*Kerry*	3·31	·93	24	28	·32	16	12
Waterford (Brook Lodge)	*Waterford*	2·54	·57	15	22	·22	16	6
Nenagh (Castle Lough)	*Tipperary*	2·51	1·11	28	44	·40	16	15
Ennistymon House	*Clare*	2·75	1·21	31	44	·35	16	14
Gorey (Courtown House)	*Wexford*	2·19	·56	14	26	·28	16	5
Abbey Leix (Blandsfort)	*Queen's Co.*	2·61	·75	19	29	·22	22	11
Dublin (FitzWilliam Square)	*Dublin*	1·90	·80	20	42	·23	17	11
Mullingar (Belvedere)	*Westmeath*	2·37	1·06	27	45	·30	22	8
Woodlawn	*Galway*	2·45	1·19	30	49	·28	20	11
Crossmolina (Enniscoe)	*Mayo*	3·14	2·48	63	79	·42	16	13
Collooney (Markree Obsy.)	*Sligo*	2·64	1·77	45	67	·39	16	13
Seaforde	*Down*	2·62	1·47	37	56	·36	13	10
Ballymena (Harryville)	*Antrim*	2·64	1·47	37	56	·33	14	12
Omagh (Edenfel)	*Tyrone*	2·63	1·72	44	65	·27	22	15

* Also 16. † Also 24. ‡ Also 18 § Also 22.

Supplementary Rainfall, April 1921.

Div.	STATION.	RAIN. in.	RAIN. mm.	Div.	STATION.	RAIN. in.	RAIN. mm.
II.	Ramsgate	1·03	26	XII.	Langholm, Drove Rd.	1·72	44
,,	Sevenoaks, Speldhurst	1·43	36	XIII.	Selkirk, Hangingshaw	·96	24
,,	Hailsham Vicarage	1·38	35	,,	North Berwick Res.	·72	18
,,	Totland Bay, Aston	·83	21	,,	Edinburgh, Royal Ob.	·61	15
,,	Ashley, Old Manor Ho.	1·37	35	XIV.	Biggar	·96	24
,,	Grayshott	·96	24	,,	Leadhills	1·99	51
,,	Ufton Nervet	·99	25	,,	Maybole, Knockdon	2·10	53
III.	Harrow Weald, Hill Ho.	1·05	27	XV.	Dougarie Lodge	1·41	36
,,	Pitsford, Sedgebrook	1·22	31	,,	Inveraray Castle	3·21	81
,,	Chatteris, The Priory.	1·06	27	,,	Holy Loch, Ardnadam	2·57	65
IV.	Elsenham, Gaunts End	1·77	45	XVI.	Loch Venachar	1·65	42
,,	Lexden, Hill House	1·45	37	,,	Glenquey Reservoir	2·20	56
,,	Aylsham, Rippon Hall	1·56	40	,,	Loch Rannoch, Dall	·68	17
,,	Swaffham	1·57	40	,,	Trinafour	1·19	30
V.	Devizes, Highclere	·68	17	,,	Coupar Angus	·92	23
,,	Weymouth	·89	23	,,	Montrose Asylum	1·11	28
,,	Ashburton, Druid Ho.	·82	21	XVII.	LogieColdstone,Loanh'd	1·26	32
,,	Cullompton	·67	17	,,	Fyvie Castle	1·61	41
,,	Hartland Abbey	·96	24	,,	Grantown-on-Spey	1·32	33
,,	St. Austell, Trevarna	1·08	27	XVIII.	Cluny Castle	1·59	40
,,	North Cadbury Rec.	·88	22	,,	Loch Quoich, Loan	6·80	173
,,	Cutcombe,Wheddon Cr.	1·32	33	,,	Drumnadrochit	2·95	75
VI.	Clifton, Stoke Bishop.	·82	21	,,	Glenelg Manse	1·92	49
,,	Ledbury, Underdown.	·87	22	,,	Skye, Dunvegan	3·32	84
,,	Shifnal,HattonGrange	1·65	42	,,	Glencarron Lodge	3·14	80
,,	Ashbourne, Mayfield	1·58	40	,,	Dunrobin Castle	..	..
,,	Barnt Green, Upwood	·94	24	XIX.	Tongue Manse	1·39	35
,,	Blockley, Upton Wold	1·13	29	,,	Melvich Schoolhouse	1·04	26
VII.	Grantham, Saltersford	1·03	26	,,	Loch More, Achfary	4·94	125
,,	Louth, Westgate	1·33	34	XX.	Dunmanway Rectory	1·16	30
,,	Mansfield, West Bank	·98	25	,,	Mitchelstown Castle	1·00	25
VIII.	Nantwich, Dorfold Hall	1·14	29	,,	Gearahameen	2·70	69
,,	Bolton, Queen's Park.	2·41	61	,,	Darrynane Abbey	1·48	38
,,	Lancaster, Strathspey.	1·58	40	,,	Clonmel, Bruce Villa	·56	14
IX.	Wath-upon-Dearne	·83	21	,,	Cashel, Ballinamona	·68	17
,,	Bradford, Lister Park.	1·29	33	,,	Roscrea, Timoney Pk.	·86	22
,,	West Witton	1·01	26	,,	Foynes	·90	23
,,	Scarborough, Scalby	1·63	41	,,	Broadford, Hurdlesto'n	1·21	31
,,	Middlesbro', Albert Pk.	1·00	25	XXI.	Kilkenny Castle	·61	16
,,	Mickleton	·90	23	,,	Rathnew, Clonmannon	·47	12
X.	Bellingham	·74	19	,,	Hacketstown Rectory	·92	23
,,	Ilderton, Lilburn	·64	16	,,	Balbriggan, Ardgillan	·78	20
,,	Orton	1·08	27	,,	Drogheda	·54	14
XI.	Llanfrechfa Grange	·85	22	,,	Athlone, Twyford	1·16	30
,,	Treherbert,Tyn-y-waun	1·87	47	XXII.	Castle Forbes Gdns.	1·12	28
,,	Carmarthen,The Friary	1·74	44	,,	Ballynahinch Castle	2·02	51
,,	Fishg'rd,Goodwick Stn.	·90	23	,,	Galway Grammar Sch.	1·35	34
,,	Lampeter, Falcondale	1·60	41	XXIII.	Westport House	1·66	42
,,	Cray Station	2·50	63	,,	Enniskillen, Portora	1·03	26
,,	B'ham W.W.,Tyrmyndd	1·90	48	,,	Armagh Observatory	·90	23
,,	Lake Vyrnwy	2·51	64	,,	Warrenpoint	·95	24
,,	Llangynhafal, P. Drâw	1·63	41	,,	Belfast, Cave Hill Rd.	1·50	38
,,	Oakley Quarries	3·44	87	,,	Glenarm Castle	1·71	43
,,	Dolgelly, Bryntirion	2·15	55	,,	Londonderry, Creggan	1·98	50
,,	Snowdon, L. Llydaw	..	..	,,	Sion Mills	1·54	39
,,	Lligwy	1·84	47	,,	Milford, The Manse	1·94	49
XII.	Stoneykirk,ArdwellHo.	1·12	28	,,	Narin, Kiltoorish	1·55	39
,,	Carsphairn, Shiel	2·81	71	,,	Killybegs, Rockmount	2·21	56

Climatological Table for the

STATIONS	PRESSURE		TEMPERATURE							
			Absolute				Mean Values			
	Mean of Day M.S.L.	Diff. from Normal	Max.	Date	Min.	Date	Max.	Min.	½ max. and min.	Diff. from Normal
	mb.	mb.	°F.		°F.		°F.	°F.	°F.	°F.
London, Kew Observatory	1019·4	+5·2	58	15	24	23	49·6	36·9	43·3	−0·7
Gibraltar	1018·5	+2·0	69	4	47	30	64·6	55·0	59·8	+0·1
Malta	1016·4	+0·7	74	3	51	21	62·7	58·6	60·7	−2·3
Sierra Leone	1012·8	+1·7	91	2, 19	69	3, 9	88·1	72·1	80·1	−1·1
Lagos, Nigeria	1013·3	+2·5	89	11	70	22	86·6	74·9	80·7	−0·6
Kaduna, Nigeria	1013·3	+3·1	91	4, 18, 23	54	30	88·7	64·0	76·3	+1·3
Zomba, Nyasaland	1009·8	+0·8	94	27	55	4	85·9	64·5	75·2	+0·1
Salisbury, Rhodesia	1008·5	−1·1	95	25, 26	52	3	87·3	57·7	72·5	+1·6
Cape Town	1015·4	−0·3	87	27	49	29	75·9	57·0	66·5	+3·4
Johannesburg	1012·2	+0·8	85	25	47	1	76·5	54·2	65·3	+1·9
Mauritius	..	..	..	..	..	..	..	..	..	..
Bloemfontein	..	..	94	24	45	27	85·4	56·7	71·1	+2·7
Calcutta, Alipore Obsy.	1011·9	−1·4	88	3	56	28	85·6	65·4	74·5	+1·4
Bombay	1009·8	−2·1	93	26	71	30	89·5	74·6	82·1	+1·8
Madras	1010·1	−1·6	92	9	68	30	84·5	73·9	79·2	+0·5
Colombo, Ceylon	1009·3	−0·8	88	15	71	29	84·8	74·1	79·5	−0·8
Hong Kong	1015·9	−1·7	83	4	61	26	75·0	67·4	71·2	+1·5
Sydney	1015·3	+1·6	98	24	55	7	77·7	61·4	69·5	+2·5
Melbourne	..	..	..	..	..	..	..	..	..	..
Adelaide	1016·0	+0·9	93	15, 26	46	2	77·4	56·0	66·7	−0·2
Perth, Western Australia	1014·3	−1·0	97	23	52	8	81·9	59·8	70·9	+5·2
Coolgardie	1013·5	+0·4	99	17	44	10	85·4	56·9	71·1	+0·3
Brisbane	1015·9	+1·6	90	20	58	1	82·2	65·1	73·7	+0·2
Hobart, Tasmania	1010·5	+1·2	78	14	38	2	64·5	47·9	56·2	−1·0
Wellington, N.Z.	1009·0	−2·6	68	28	39	2	61·0	49·6	55·3	−1·6
Suva, Fiji	1010·9	−0·2	88	8	68	11	82·6	71·6	77·1	−0·1
Kingston, Jamaica	1012·8	+0·1	92	5	69	17	89·1	72·3	80·7	+1·4
Grenada, W.I.	1011·7	+1·1	90	27	73	sev.	83·4	74·6	79·0	−0·3
Toronto	1019·8	+3·0	62	9	20	12, 13	42·0	31·5	36·7	+0·4
Winnipeg	1020·7	+4·0	47	5	0	9	32·9	17·8	25·3	+4·5
St. John, N.B.	1018·3	+4·4	57	3	14	29	39·8	26·9	33·3	−3·4
Victoria, B.C.	1016·3	+0·8	58	18	35	10	50·5	41·6	46·1	+1·7
	September.									
Perth, Western Australia	1017·4	−0·4	84	26	43	29	67·8	50·2	59·0	+0·8

LONDON, KEW OBSERVATORY.—Mean speed of wind 5·8 mi/hr ; 16 days with fog.
GIBRALTAR.—2 days with thunder heard, 5 days with gale.
MALTA.—Wind direction variable, mean speed 8·8 mi/hr.
SIERRA LEONE.—Prevailing wind direction SW.
SALISBURY, RHODESIA.—Prevailing wind direction NE.
HONG KONG.—Prevailing wind direction ENE. ; mean speed 1·0 mi/hr.

British Empire, November 1920.

Diff. from Normal °F.	TEMPERATURE Absolute Max. in Sun °F.	TEMPERATURE Absolute Min. on Grass °F.	Relative Humidity %	Mean Cloud Am'nt 0–10	PRECIPITATION Amount in.	PRECIPITATION Amount mm.	PRECIPITATION Diff. from Normal mm.	PRECIPITATION Days	BRIGHT SUNSHINE Hours per day	BRIGHT SUNSHINE Percentage of possible	STATIONS
-0·7	93	19	87	6·4	1·32	34	− 22	12	1·6	18	London, Kew Observatory.
-0·1	120	41	79	5·6	9·90	251	+ 90	14	..	..	Gibraltar.
-2·3	123	..	82	7	8·62	219	+138	20	3·3	32	Malta.
-1·1	..	..	73	5·0	2·25	57	− 78	7	..	..	Sierra Leone.
-0·6	159	63	81	6·5	2·79	71	+ 5	12	..	..	Lagos, Nigeria.
+1·3	..	..	64	..	0·43	11	+ 10	1	..	..	Kaduna, Nigeria.
+0·1	..	..	77	4·6	3·10	79	− 63	6	..	..	Zomba, Nyasaland.
+1·6	153	48	54	2·4	3·04	77	− 22	9	..	..	Salisbury, Rhodesia.
+3·4	..	..	62	4·9	0·77	20	− 7	9	..	..	Cape Town.
+1·9	..	43	60	4·2	3·92	100	− 8	15	9·3	70	Johannesburg.
..	..	..	..	..	..	..	..	..	..	..	Mauritius.
+2·7	..	..	48	2·8	0·98	25	− 33	6	..	..	Bloemfontein.
+1·4	..	47	52	1·7	trace	trace	− 14	0	..	..	Calcutta, Alipore Obsy.
+1·8	139	61	60	1·7	0·00	0	− 10	0	..	..	Bombay.
+0·5	..	..	88	7·4	30·08	764	+439	18	..	..	Madras.
−0·8	162	67	76	9·0	14·49	368	+ 61	26	..	..	Colombo, Ceylon.
+1·5	..	..	73	7·1	7·05	179	+143	8	5·0	46	Hong Kong.
+2·5	147	48	61	5·7	2·06	52	− 22	8	..	..	Sydney.
..	..	..	..	..	..	..	..	..	..	..	Melbourne.
−0·2	152	35	52	5·3	2·29	58	+ 28	8	..	..	Adelaide.
+5·2	160	42	51	3·6	0·22	6	− 14	5	..	..	Perth, Western Australia.
+0·3	163	42	35	3·5	0·66	17	0	4	..	..	Coolgardie.
+0·2	151	52	65	5·1	6·28	160	+ 65	14	..	..	Brisbane.
−1·0	148	34	62	6·8	1·69	43	− 22	20	..	..	Hobart, Tasmania.
−1·6	139	29	76	6·4	2·70	69	− 23	15	5·4	37	Wellington, N.Z.
−0·1	..	..	79	6·7	4·10	104	−138	17	..	..	Suva, Fiji.
+1·4	..	..	75	5·6	0·37	9	− 71	5	..	..	Kingston, Jamaica.
−0·3	139	..	81	5·8	11·49	292	+ 84	25	..	..	Grenada, W.I.
+0·4	..	..	84	7·3	3·80	97	+ 22	16	..	..	Toronto.
+4·5	..	..	91	5·5	1·50	38	+ 14	6	..	..	Winnipeg.
−3·4	..	..	78	4·9	3·54	90	− 22	13	..	..	St. John, N.B.
+1·7	..	..	88	7·5	3·11	79	− 85	16	..	..	Victoria, B.C.
						September.					
+0·8	..	36	67	4·2	2·53	64	− 21	12	..	..	Perth, Western Australia.

BOMBAY.—October pressure should read 1009·5, −0·2

Madras.—6 days with thunder heard.

COLOMBO, CEYLON.—Wind direction variable, mean speed 4·1 mi/hr. 7 days with thunder heard.

GRENADA.—Prevailing wind direction E.; 1 day with thunder heard.

TORONTO.—7 days with fog.

WINNIPEG.—6 days with fog.

VICTORIA.—1 day with fog.

strip along the south coast of Ireland received only 25 per cent. of the average. Considerable areas in the Thames Valley and in the east of Great Britain between Yorkshire and Perthshire, as well as in the south-east of Ireland, had a total rainfall of less than 25 mm. (1 inch). Only restricted areas in England, Wales, and Ireland had as much as 50 mm. (2 inches). The West Highlands were, however, rather wetter.

The general rainfall, expressed as a percentage of the average, was:—England and Wales, 59; Scotland, 61; Ireland, 46; British Isles, 56.

In London (Camden Square) the month was fine and pleasantly mild, but with a cold snap and snow showers between the 15th and 17th. The mean temperature was 49·5° F., or 1·5° F. above the average. Duration of rainfall, 25·1 hours. Evaporation, 1·91 inches.

Weather Abroad: April, 1921.

THE serious drought which had prevailed in France and Switzerland throughout March was broken by welcome rains in Switzerland on April 4th, when the Alps again became snow-covered, and in France on April 14th. Temperature in France, which had been unusually high, fell rapidly, and on the 15th the rain turned to snow and sleet, which lasted for several days. About this time frost did considerable damage to the fruit trees and vines in Holland and Switzerland. On the 19th three waterspouts were seen over the Mediterranean from Mentone. Further east, following a gale in the Mediterranean, heavy rainfall caused a sudden rise of the Tigris, which burst its banks and damaged the railway between Kut-el-Amara and Bagdad. In America the tornado season (April to July) began with a visitation in Southern Arkansas on the night of April 15th–16th, causing the loss of 50 lives, besides hundreds injured and much material damage. The district was at the time in the south-eastern quadrant of a fairly deep depression; this is the most favourable condition for the occurrence of tornados, a warm southerly surface current being overlain by a colder westerly upper current.

A severe eruption of the volcano of Popocatepetl, in Mexico, occurred early in April. This is a recrudescence of the activity which began in the spring of 1920, after 200 years of quietude. In the past the dust associated with volcanic eruptions has been responsible for considerable meteorological effects, especially a diminution in the heat and light from the sun, and brilliant sunset coloration, a noteworthy example being Krakatoa in 1883, and it will be interesting to observe if similar effects follow in this case.